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POSS® COATINGS AS REPLACEMENTS FOR SOLAR CELL COVER GLASSES

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I. Introduction

Presently, solar cells are covered with Ce-doped microsheet cover glasses that are attached with Dow Corning DC 93-500 silicone adhesive. Various antireflection coatings are often applied to the cover glass to increase cell performance. This general approach has been used from the beginning of space exploration. However, it is expensive and time consuming. Furthermore, as the voltage of solar arrays increases, significant arcing has occurred in solar arrays, leading to loss of satellite power. The cause has been traced to differential voltages between strings and the close spacing between them with no insulation covering the edges of the solar cells. In addition, this problem could be ameliorated if the cover glass extended over the edges of the cell, but this would impact packing density. An alternative idea that might solve all these issues and be less expensive and more protective is to develop a coating that could be applied over the entire array. Such a coating must be resistant to atomic oxygen for low earth orbits below about 700 km, it must be resistant to ultraviolet radiation for all earth and near-sun orbits and, of course, it must withstand the damaging effects of space radiation. Coating flexibility would be an additional advantage.

Based on past experience, one material that has many of the desired attributes of a universal protective coating is the Dow Corning DC 93-500. Of all the potential optical plastics, it appears to be the most suitable for use in space. As noted above, DC 93-500 has been extensively used to attach cover glasses to crystalline solar cells and has worked exceptionally well over the years. It is flexible and generally resistant to electrons, protons and ultraviolet (UV and VUV) radiation; although a VUV-rejection coating or VUV-absorbing ceria-doped cover glass may be required for long mission durations. It can also be applied in a thin coating (< 25 µm) by conventional liquid coating processes. Unfortunately, when exposed to atomic oxygen (AO) DC 93-500 develops a frosty surface. Such frosting can lead to a loss of light transmitted into the cells and destroy the essential clarity needed for a concentrator lens.

Thus, the investigation has turned to a new class of materials. These materials must be glass-like in their final state, resist AO, UV/VUV and be resistant to electron and proton radiation. Flexibility would be a benefit, but is not essential. The initial investigation of these new materials has been directed toward determining their resistance to proton irradiation. Many space missions are only possible by flying through the heart of the Van Allen radiation belts. One mission in particular is a solar electric propulsion mission that moves a satellite from low earth orbit (LEO) to another location. The location may be geosynchronous earth orbit (GEO) as for a communications satellite, a lunar orbit like ESA's Smart 1. While these missions take more time than using a chemical kick motor, the costs are substantially lower. Another class of missions that is of interest is those that would benefit from observing the earth and that fly either elliptical orbits that pass through the belts or that stay within the belts. This initial focus is on the resistance to 2 MeV protons because they are absorbed in glass-like materials in about 75 µm. Protons are exceptionally damaging because most of the damage occurs at the end of their path, thus causing maximum damage in a very narrow region of the material. If the new materials can withstand this punishment, the next step will be to assess their resistance to VUV/UV illumination.

The New Option

A new class of materials has recently been discovered during the search for improvements in optical plastics. These new polymeric building block materials are called "polyhedral oligomeric silsequioxanes". They were developed by the Air Force Research Laboratories at Edwards Air Force Base in 1998. The technology is exclusively manufactured by Hybrid Plastics Inc. (Hattiesburg, MS) under the acronym POSS® nanocomposites. This technology has several significant advantages that are relevant to solar cell use. The glass-like composition of POSS